

EPA Coalbed Methane Outreach Program Technical Options Series

COAL MINE METHANE STORAGE IN ABANDONED MINES



Leyden Mine Underground Natural Gas Storage Facility Near Denver, Colorado
(Photo courtesy of Public Service Company of Colorado)

PRIMARY BENEFITS OF STORING COAL MINE METHANE IN ABANDONED MINES...

- ◆ Allows project operators to store excess gas and ensure consistent deliverability
- ◆ Can use the methane for peak shaving (supplying gas to market during peak demand)
- ◆ Could improve the overall economic viability of many coal mine methane projects

Peak load gas storage could improve the overall economic viability of many coal mine methane projects

More than 18,000 coal mines abandoned after 1950 are located near the 22 gasiest mines

Abandoned mine gas storage may be particularly advantageous to larger coal mine methane projects that inject gas into commercial pipelines

Why Consider Storing Coal Mine Methane in Abandoned Mines?

The use of abandoned coal mines to store coal mine methane and conventional natural gas can enhance the economics of coal mine methane projects. Historically, the natural gas industry has used storage facilities to store gas during periods of low demand, particularly the summer months, and withdraw it during periods of peak demand, typically in the winter. More recently, gas storage units include peak load facilities that are typically capable of high deliverability with flexibility in injection and withdrawal cycles.

Accurate predictions of increases in gas demand are critical to market stability, particularly during winter months. Unseasonable weather which leads to stored gas withdrawals can send natural gas prices soaring. Storage facilities can benefit from these situations by selling gas at peak prices. Demand for natural gas storage facilities has increased due to: 1) the high cost of constructing pipeline capacity, 2) FERC Order 636, and 3) increased natural gas demand.

To date, there has been no storage of coal mine methane in abandoned mines. In fact, there is only one abandoned coal mine storage facility in the United States--the Leyden Mine Underground Gas Storage Facility, operated by Public Service Company of Colorado (PSCO). The facility, established in the late 1950s, remains a key component of Denver's natural gas supply system. Distrigaz, a Belgian gas company, has more extensive experience with storing gas in abandoned mines. Two facilities in the Campine coal fields store in excess of 10 billion cubic feet of imported natural gas for use during peak demand periods.

Continued success with conventional natural gas storage at the Leyden Mine and those in Belgium suggests that there may be many opportunities for storage of coal mine methane in abandoned mines located near active coal mines. The ability to store gas would benefit coal mine methane projects that market recovered gas by injecting it into commercial pipelines. Specifically, these facilities would provide project operators with the ability to store excess gas, sell gas during peak demand times, and assure consistent product deliverability to dedicated customers.

Gas storage could also enhance the viability of methane-fueled power projects. A gas storage facility permits the operator to supply gas at a nominal leveled price, improving the economics of a power generation facility. The profitability of a power generation project ultimately depends on the cost of fuel, and the sales price the operator can receive for electricity during times of low ("off peak") electricity demand. In addition to selling power to other consumers, a coal mine could use the electricity on-site to supplement power supplied by electric utilities.

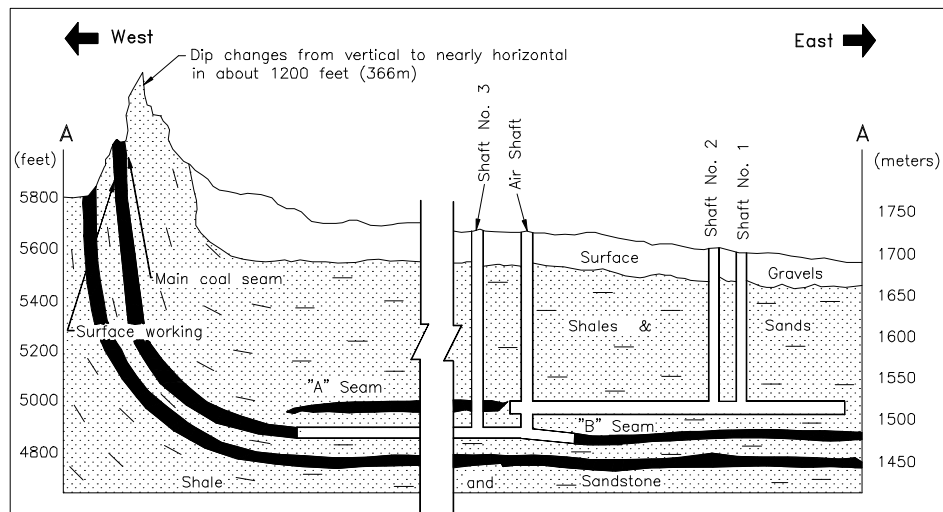
Abandoned coal mines favorable for coal mine methane storage would typically have mined-out seams deep below the surface, and undisturbed surrounding strata (e.g., room and pillar without extensive pillar extraction). In some instances, there may be lower development and operating costs with larger scale facilities, due to economies of scale. More important than size, however, is the facility's proximity to gas sources and markets which affects its ability to respond to changing markets.

Many abandoned coal mines have sufficient capacity to store more gas than the typical active mine produces, and could serve as storage facilities for conventional natural gas as well. This added capability could further enhance economics of the storage project by increasing the ability to maximize gas sales during peak gas prices. It could also increase opportunities to use medium quality coal mine methane, by blending it with gas that exceeds pipeline quality (see U.S. EPA's Technical Options case study *Upgrading Medium Quality Coal Mine Gas by Blending and Spiking*).

The Leyden Mine Underground Natural Gas Storage Facility

The Leyden Mine contains two horizontal coal seams, 8 to 10 feet thick, one 50 feet above the other. Room and pillar mining left a void of 150 million cubic feet (mmcf) some 700-1,000 feet below the surface. Operating pressure may vary from 60 pounds per square inch (psi) to 250 psi, but averages 165 psi.

Water-saturated shale and sandstone surrounding the coal seams provides the seal that keeps the gas from seeping out of the mine. Storage capacity of the facility is 3.0 billion cubic feet (bcf), and the working capacity is 2.2 bcf.



East-West Section of the Leyden Mine (modified from PSCo brochure)

Opportunities for Coal Mine Methane Storage in Abandoned Mines

Many active gassy coal mines are in close proximity to abandoned underground mines, and the availability of high-deliverability gas storage nearby could enhance coal mine methane recovery and use. Because abandoned coal mines are generally shallow, storage pressures, and hence storage capacities tend to be low relative to conventional depleted gas reservoirs and aquifer storage facilities. However, the potential for added storage via re-adsorption of methane by the unmined coal can significantly increase storage capacity. Belgian operators indicate that this effect increases storage volumes in their abandoned coal mine storage facilities by a factor of ten.

EPA has prepared a report titled *Technical and Economic Assessment of Coalbed Methane Storage in Abandoned Coal Mine Workings*. The table below shows estimated capital and operating costs.

Comparison of Development and Operating Costs for Conventional vs. Abandoned Mine Storage

	Conventional Storage Facilities	Hypothetical Abandoned Mine Storage Facility
Development Cost	\$2-4/mcf (\$70-135/1000 m ³) for depleted reservoirs and aquifer storage \$7-14/mcf (\$245-500/1000 m ³) for mined caverns	\$5.90 - \$6.50/mcf (\$208-\$230/1000 m ³)
Operating Cost*	\$0.20-4.50/mcf of gas sales (\$7-159/1000 m ³)	\$2.00-\$2.80/mcf of gas sales (\$71-99/1000 m ³)
* Per single cycles. Multiple cycles further reduce operating costs.		

The EPA report includes preliminary economic analysis for hypothetical abandoned mine storage facilities operating with oversupply gas stock from associated large scale coal mine methane projects. An \$11 million capital investment in a facility that can withdraw gas at 80 mmcf/d (2.3 million m³/d), cycling 35 maximum gas withdrawal days per year, and selling gas at an average annual peak price of \$2.50/1000 ft³ (\$88.29/1000 m³), would yield the following results:

- internal rate of return greater than 15%;
- net present values greater than \$1 million (discount rate 5%);
- project payback period of less than five years.

For More Information...

The use of abandoned coal mines to store coal mine methane can enhance the economics of coal mine methane projects, allowing project operators to store oversupply gas, and sell it during periods of peak demand (and consequently higher gas prices). To obtain the EPA report *Technical and Economic Assessment of Coalbed Methane Storage in Abandoned Coal Mine Workings*, or to obtain additional information about this and other uses for coal mine methane, contact:

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